Statistical and Hydrochemical Analysis of Surface Water: A Case Study of the Mediterranean Sea and the Great Manmade River in Libya

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Abstract: ***The current research relies on the use of the statistical method to determine and study what affects the concentrations of constituent elements in the surface water sources in the study area, and from the study area 49 water samples (The Mediterranean Sea and the Great Manmade River in Libya) distributed over the research areas were collected to determine the main elements a chemical analysis (anions and cations) was performed. Also, to determine the correlation coefficient for the chemical composition of water in the main components, a statistical search is carried out using (S. P. S. S 20 programs, as well as to find out the variables that refer to the effective basic components), And by using the (Q - MODE) method, the statistical analysis of the samples resulted from dividing them into three categories according to their chemical components that are similar in properties.***

Keywords: Factor Analysis, S. P. S. S, Major Ions

1. Introduction

Hydrochemical studies are one of the important means that help explain and understand the hydrogeological conditions in the studied area and are used as one of the indirect methods in regional studies in order to understand the geological structure and history of the region And directing all studies aimed at investing water in various fields of the national economy, and this is what many hydrochemical studies of water lack .

Many studies have indicated that the chemical composition of water changes with the change of time and place, and there are many factors that control the chemistry of water .[1]

What is meant by factors that form the chemical composition of water is the totality of natural conditions such as climate, vegetation, aquatic life activity, geology of the region, and human activity that limit the nature of dissolved substances in water and the physicochemical processes that form this composition [1, 2, 3, 4].

Where water is affected by the nature of geological processes and rock formations in the region [5] and climate, especially rainfall, plays an important role in changing the concentrations of the main chemical elements of water [6] and forests also have a clear role in that [7]. Man also contributes, especially through his agricultural activities, by using pesticides and conducting fertilization operations in the lands, by changing the concentrations of the main elements of water [8].

Sedimentary and volcanic rocks are exposed in the area, and its ages go back to the Triassic and even the Quaternary. The volcanic rocks dating back to the Pliocene form basaltic covers located on the tops of the hills, as they cover a large part of the study area and consist of pyroclastic materials at the bottom, crowned in all regions by basaltic lava composed of olivine basalts, in addition to the ophiolite area covered with trees and dense forests.

Research importance and objectives :

The research is of particular importance due to the great expansion of various development activities and the increase in pressures on water resources, which warns of the emergence of some water problems represented primarily by the qualitative deterioration of these resources apart from their limitations and the association of renewable quantities with climatic factors that have witnessed in recent years significant changes accompanied by a decline in rainfall rates.

The research presents a contribution to assessing the hydrogeochemical situation of The Mediterranean Sea and the Great Manmade River in Libya by identifying the basic elements of the chemical composition of this water, in addition to conducting an analysis by multivariate statistical methods such as factorial and cluster analysis, which are common in hydrochemical studies [10, 11], This is to show the change in the concentrations of the main ions in 49 sites, which contributes to knowing the conditions and variables that refer to the basic factors affecting the chemical properties of surface water and The Mediterranean Sea and the Great Manmade River in Libyawater.

Research methods and materials

The results of chemical analyzes were used for 49 sites between seas, rivers and The Mediterranean Sea and the Great Manmade River in Libya distributed to include the research area The analyzes were carried out in the Directorate of Water Resources to determine the basic elements (anions and cations), Advanced computer programs S. P. S. S were also used for evaluation and statistical analysis Data and factor analysis were entered using the basic components method to determine the factors. affecting the concentrations of ions, which is one of the common statistical methods in dealing with chemical data to about 95% for surface water samples and The Mediterranean Sea and the Great Manmade River in Libya, where each of the bicarbonate, sulfate, chlorine, sodium, calcium, potassium and magnesium were analyzed, and we drew charts showing the change in the values of these electrolytes.

Then we used statistical analysis to find out the variables that indicate the basic factors affecting the chemical properties in order to optimally plan the different uses of surface water resources and The Mediterranean Sea and the Great Manmade River in Libya in the region.

By using cluster analysis, we identified the correlations between the sites and separated them into groups with similar characteristics.

determine the relationship between a number of variables at the same time [1 - 10], with only one operator.

We also used cluster analysis, which is one of the most important uses of statistics in the field of hydrogeology, and it is implemented in more than one method [12, 13, 14], according to our reliance in the search on Vairemax, and we performed statistical analysis using Cluster analysis / Q Mode to determine the correlation between samples and separate them into groups with similar characteristics.

2. Results and Discussion

After conducting chemical analyzes and identifying the main electrolytes that constitute the main part of the chemical composition of natural water, and their percentage reaches

Table 1: Monthly averages of quantitative analysis results in mg/L and some field measurements of surface and The Mediterranean Sea and the Great Manmade River in Libya water sample

Na^+	K^+	Ca^{2+}	Mg^{2+}	HCO_3^-	SO_4^{2-}	Cl^-	
50.30	6.25	142.90	61.52	331.11	206.36	40.45	**1**
65.98	8.77	270.66	38.01	320.83	401.66	40.71	**2**
6.00	0.50	40.00	36.00	240.00	4.00	15.00	**3**
25.26	4.50	45.66	44.73	285.00	70.75	28.33	**4**
12.00	2.00	68.00	24.00	18.00	25.00	240.00	**5**
15.00	3.00	72.00	24.00	32.00	25.00	210.00	**6**
38.00	3.00	68.00	26.40	45.00	55.00	170.00	**7**
35.45	5.10	36.92	67.35	390.00	47.38	37.50	**8**
21.00	4.00	84.00	17.00	68.00	25.00	200.00	**9**
31.00	3.00	84.00	25.20	45.00	40.00	190.00	**10**
46.00	6.00	104.00	34.00	110.00	55.00	210.00	**11**
8.00	0.63	49.33	31.33	251.66	12.00	20.00	**12**
11.00	0.70	52.00	0.00	260.00	18.00	15.00	**13**
21.00	1.31	102.00	13.96	293.33	12.66	41.66	**14**
5.00	0.40	60.00	17.00	270.00	5.00	40.00	**15**
11.00	0.80	60.00	17.00	280.00	15.00	15.00	**16**
38.00	2.70	96.00	26.00	420.00	12.00	40.00	**17**
24.33	1.40	58.00	19.33	225.00	13.00	28.33	**18**
7.28	0.55	61.14	28.11	240.00	6.42	21.42	**19**
36.00	2.30	64.00	36.00	310.00	0.00	45.00	**20**
5.75	0.50	54.00	17.25	202.50	10.00	20.00	**21**
10.00	0.70	40.00	67.00	270.00	7.00	20.00	**22**

Na^{+}	K^{+}	Ca^{2+}	Mg^{2+}	HCO_3^{-}	SO_4^{2-}	Cl^{-}	
20.00	1.20	76.00	19.00	290.00	23.00	25.00	23
23.00	1.00	126.00	1.20	350.00	37.00	25.00	24
9.30	0.50	65.00	27.6	137.75	139.75	8.75	25
23.00	1.76	69.33	21.73	250.00	18.00	20.00	26
8.00	0.60	68.00	31.00	340.00	12.00	15.00	27
14.00	0.90	92.00	43.00	380.00	13.50	32.5	28
8.00	1.00	64.00	26.40	240.00	23.00	20.00	29
10.26	0.66	70.66	25.66	176.66	101.00	13.33	30
8.50	0.00	72.00	28.8	310.00	15.00	20.00	31
8.03	0.30	63.33	22.66	153.33	98.33	13.33	32
8.50	1.00	76.00	26.40	280.00	17.00	20.00	33
16.50	1.12	59.00	30.50	250.00	6.75	21.25	
8.00	0.00	64.00	28.80	280.00	8.00	15.00	34
18.00	1.10	60.00	17.00	260.00	19.00	20.00	35
20.00	1.00	88.00	31.20	340.00	15.00	25.00	36
8.00	0.00	60.00	24.00	150.00	17.00	20.00	37
24.00	2.00	100.00	16.80	340.00	33.00	25.00	38
15.00	3.31	54.66	30.33	235.55	11.55	20.00	39
36.42	4.50	80.28	45.98	366.92	79.50	48.21	40
43.00	3.00	132.00	26.00	370.00	39.00	50.00	41
57.5	7.62	155.40	28.88	298.57	218.6	43.33	42
39.13	6.01	87.76	58.92	362.72	127.05	76.60	43
33.00	4.00	130.00	12.00	320.00	42.00	35.00	45
18.35	1.57	89.20	17.25	283.92	39.80	30.71	46
34.50	2.25	89.00	69.50	580.00	43.50	62.50	47
13.00	1.00	68.00	31.20	270.00	11.00	15.00	48
44.69	6.06	54.42	84.64	460.00	52.28	45.35	49

Field measurements:

TDS mg/l	COND µs/cm	pH	
751.63	1156.4	7.65	1
1057.03	1626.2	7.85	2
261.30	402.0	7.87	3
355.87	547.5	8.13	4
301.60	464.0	7.60	5
299.65	461.0	7.47	6
407.55	627.0	7.80	7
445.84	685.9	8.32	8
340.60	524.0	7.78	9
417.95	643.0	7.80	10
562.25	865.0	7.69	11
275.16	423.3	7.76	12
254.80	392.0	7.50	13
408.41	628.3	7.30	14
243.75	375.0	7.69	15
261.30	402.0	7.68	16
460.85	709.0	7.08	17
275.92	424.5	7.68	18
255.17	392.6	7.52	19
455.00	700.0	7.39	20
245.53	377.8	7.77	21
305.50	470.0	7.19	22
310.70	478.0	7.53	23
416.00	640.0	7.10	24
316.06	486.3	7.29	25

TDS mg/l	COND µs/cm	pH	
283.61	436.3	7.56	26
318.50	490.0	7.73	27
424.45	653.0	7.09	28
273.65	421.0	7.30	29
324.12	498.7	7.33	30
343.20	528.0	7.50	31
268.22	412.7	7.54	32
307.45	473.0	6.64	33
292.82	450.5	7.44	34
305.50	470.0	7.44	35
286.00	440.0	7.45	36
412.75	635.0	6.60	37
285.35	439.0	7.40	38
406.90	626.0	7.61	39
275.60	424.0	7.66	40
528.45	813.0	7.26	41
551.85	849.0	7.64	42
724.81	1115.1	7.78	43
642.14	987.9	7.76	44
490.75	755.0	7.40	45
359.40	552.9	7.30	46
644.47	991.5	8.05	47
325.00	500.0	6.90	48
575.25	885.0	7.89	49

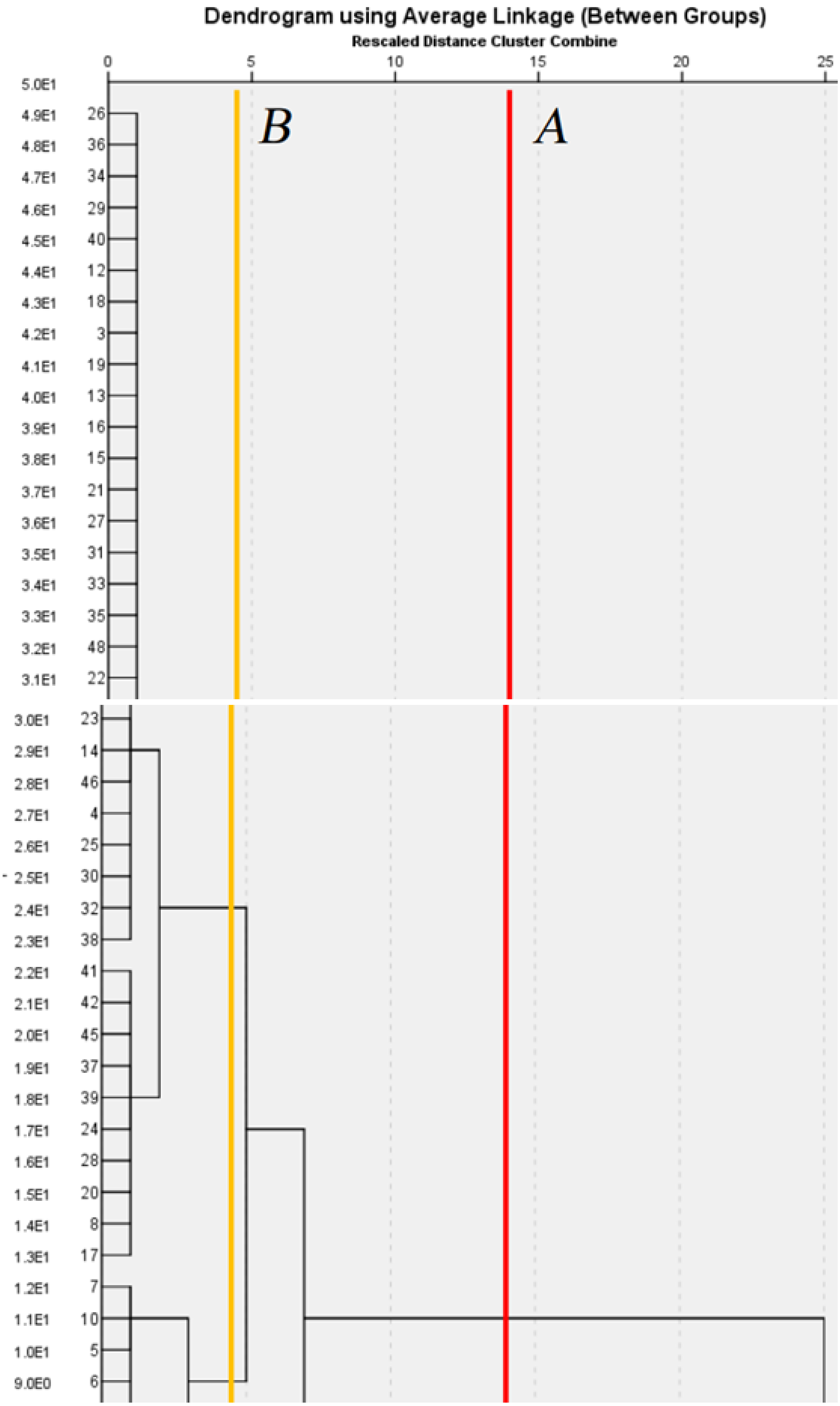
Correlations

	TDS	Na	K	Ca	Mg	HCO_3	SO_4	Cl
TDS	1							
Na	.903**	1						
K	.834**	.897**	1					
Ca	.827**	.689**	.602**	1				
Mg	.418**	.369**	.394**	-.020	1			
HCO_3	.410**	.306*	.155	.200	.474**	1		
SO_4	.795**	.647**	.697**	.773**	.207	.071	1	
Cl	.134	.254	.345*	.087	-.047	-.585**	.012	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Figure 1: Correlation coefficients between the basic chemical components of the analyzed aqueous samples


Dendrogram using Average Linkage (Between Groups)
Rescaled Distance Cluster Combine
0
5
10
15
20
25
B
A
5.0E1
4.9E1 26
4.8E1 36
4.7E1 34
4.6E1 29
4.5E1 40
4.4E1 12
4.3E1 18
4.2E1 3
4.1E1 19
4.0E1 13
3.9E1 16
3.8E1 15
3.7E1 21
3.6E1 27
3.5E1 31
3.4E1 33
3.3E1 35
3.2E1 48
3.1E1 22
3.0E1 23
2.9E1 14
2.8E1 46
2.7E1 4
2.6E1 25
2.5E1 30
2.4E1 32
2.3E1 38
2.2E1 41
2.1E1 42
2.0E1 45
1.9E1 37
1.8E1 39
1.7E1 24
1.6E1 28
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1.4E1 8
1.3E1 17
1.2E1 7
1.1E1 10
1.0E1 5
9.0E0 6

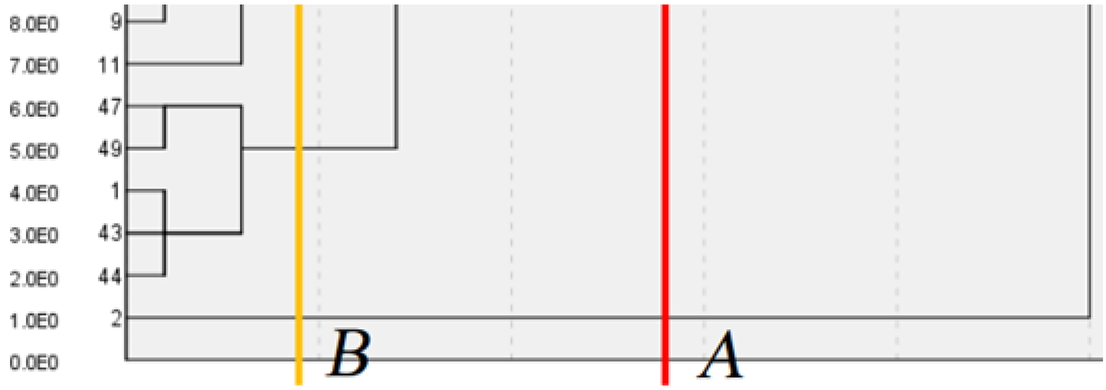

Figure 2: Q Mode statistical analysis to illustrate the correlation of the studied sites

Bicarbonate ion

The values of the bicarbonate ion in the studied samples ranged between 18.00 and 580.00 mg/L, and the values of the ion do not exceed the allowable limit in drinking water, which is 500 mg/L according to standard specifications [15] except for one site, and the presence of the bicarbonate ion in the water is due to the dissolution of the dolomitic and marl carbonate rocks Due to rain, in addition to the presence of vegetation, which affects the amount of CO2 gas, as it stabilizes it in the atmosphere .[16]

Sulfate ion:

It ranges between 4.00 and 401.66 mg/l, and does not exceed the permissible limit in drinking water, which is 250 mg/l in all sites except for one site. The reason for the high concentration is due to agricultural and industrial waste in which the concentration of salts is high. Perhaps there is a role for the presence of gypsum and anhydrite deposits or Their proximity to sites whose dissolution leads to an increase in sulfate and calcium ions.

Chlorine ion:

The concentration of chlorine in the samples ranged between 8.75 and 240.00 mg/l, and the values do not exceed the allowable limit in drinking water of 250 mg/l. However, there are somewhat high values due to a significant thickness of the clays on the surface affected by weathering, which led to the formation of flakes of halite within which it dissolves in water. It is raining, but the presence of these values of chlorine ion does not indicate anything dangerous in the water quality, as it is less than the permissible limit in drinking water.

Sodium ion:

The presence of sodium is explained by the presence of a good thickness of clays on the surface affected by the weathering process, which led to the formation of halite flakes that were dissolved by rain water, in addition to weathering with CO2 gas for plagioclases and other silicates present in the area where some rocks and basalt products are spread [14].

The values of sodium ion were rather low in the water samples, ranging between 5.00 and 65.98 mg/l, and the values did not exceed the allowable limit in drinking water, which is 200 mg/l [15].

Potassium ion:

It is similar to sodium, where potassium forms easily soluble consortia, and the potassium ion is present in water at low concentrations, ranging between 0.00 and 8.77 mg / L, and its value did not exceed the permissible limit in drinking water, which is mg / L [15].

Calcium and magnesium ion:

Their main source is filtered rain water and what this water obtains from its natural dissolution of its compounds, which are calcium carbonate, calcite, calcium carbonate, magnesium, dolomite, and plaster, and the weathering products of Javanese silica on calcium, and from the experiment of basic and suprabasic rocks, and others with regard to magnesium. The values of the anion ranged between 36.92 and 270.66 mg/L, while the values of the magnesium ion were between 1.20 and 69.5 mg/L. The calcium ion did not exceed the allowable limit in drinking water of 200 mg/L [15] except for one site, and the reason is the presence of gypsum and anhydrite deposits, which lead to Its dissolution is due to the high sulfate and calcium ions, which corresponds to what we mentioned in the sulfate ion. The values of the magnesium ion were within the permissible limit in all sites of 150 mg / L [15].

The determination of the correlation coefficients shows the following relationships:

- A positive correlation between salinity and each of the salinity electrolytes (potassium, calcium, sodium, sulfate), where the correlation coefficients are 0.83, 0.82, 0.9, 0.79, respectively.
- A strong positive correlation between potassium and sodium 0.89, which indicates the same origin of the two anions due to the presence of a significant thickness of the cartilages on the surface affected by the weathering processes, which led to the formation of halite flakes within them that dissolve in rain

And a strong positive correlation between sulfate, calcium and potassium, where the value of the correlation coefficient reached 0.77 and 0.69, and this indicates the compatibility in the distribution of these two ions (sulfate and calcium) in the water in terms of the presence of one sources for them, which are gypsum and anhydrite rocks scattered in some parts of the region and the use of potassium sulfate as a basic fertilizer for the soil Agricultural located in Almanka.

Q mode analysis shows that there are two similarity levels AA and BB.

According to the first level of similarity, AA, we distinguish an independent case, site 2, and several cases that form one group, which are the rest of the 48 sites, where site 2 is characterized by a relatively high salinity, amounting to 1057.03 mg / L, exceeding the permissible limit for drinking water, which is 1000 mg / L [15], while the rest of the sites did not exceed The value is 751.63 mg/L .

And along the similarity plane BB we distinguish:
1) The first group of 43 sites characterized by electrical conductivity less than 865.00 µs/cm.
2) The second group has five sites: 44, 43, 1, 49, and 47, with electrical conductivity between 1156.4 and 885.00 µs/cm.
3) The third group is a carrier that exceeds 1600 µs/cm at site 2. The three groups share a pH level of PH = 6.60 - 8.32.

3. Conclusions and Recommendations

The study concludes that both natural climatic factors and the lithological composition of rock formations significantly influence the chemical composition of surface water in the Mediterranean Sea and the Great Manmade River in Libya.

Human activities, particularly agriculture and industry, also play a substantial role in shaping water chemistry.

The statistical and cluster analysis of samples has provided valuable insights into the correlations between the basic components of the waters chemical composition.

The study recommends regular analysis of surface water to ensure its quality for various uses.

There is also a need for better control of fertilizer use in agriculture and careful selection of locations for future industrial establishments.

This research contributes to the understanding of hydrogeochemical conditions and aids in the optimal planning of water resource usage.

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